

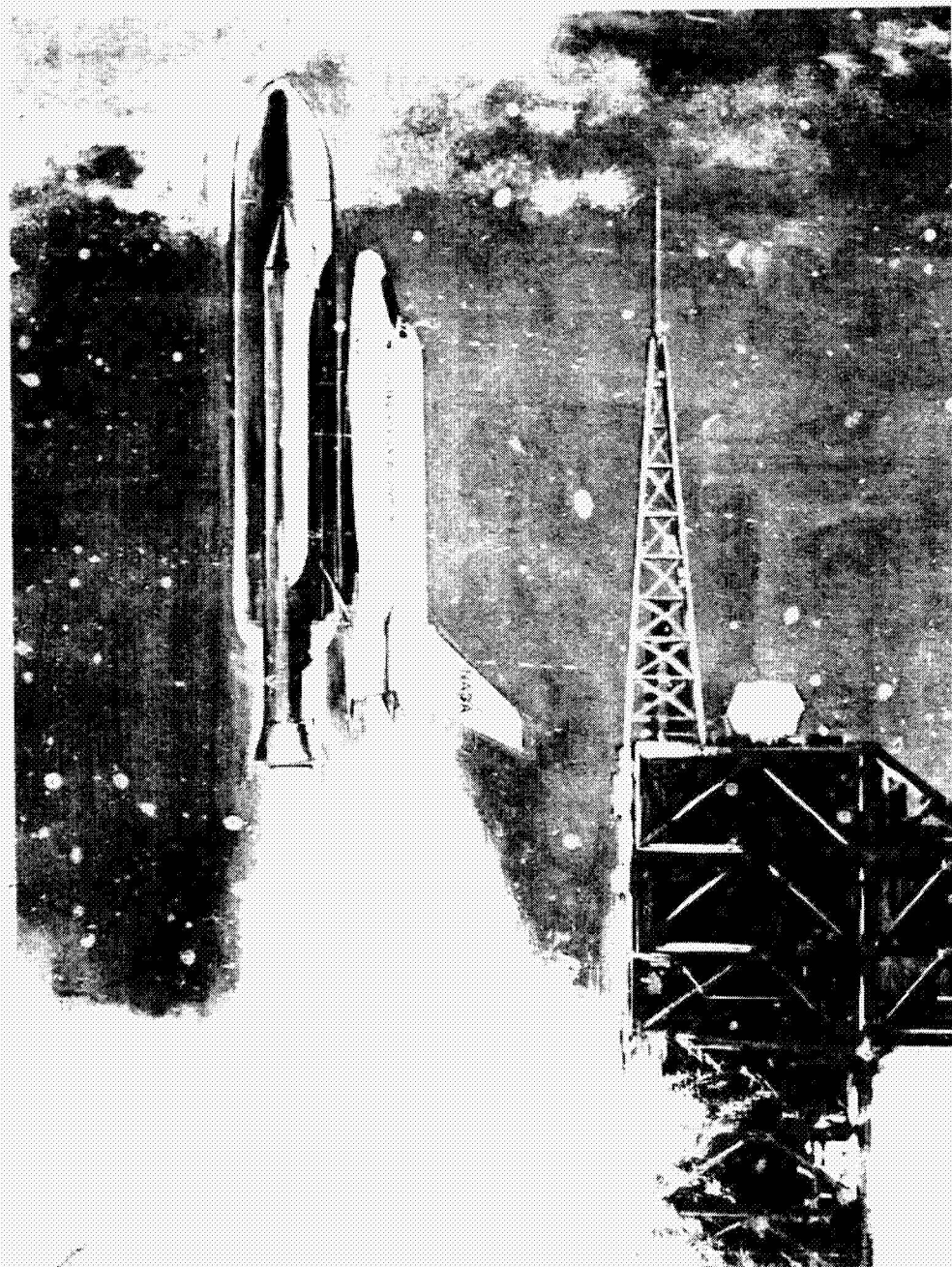
(NASA-TM-X-70384) SPACE SHUTTLE (NASA)  
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# SPACE SHUTTLE

RELEASE NO: 74-267



OCTOBER, 1974

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

## SPACE SHUTTLE FACT SHEET

### Introduction

The Space Shuttle will be a reusable space vehicle operated as a transportation system for a wide variety of space missions in low Earth orbit.

The Shuttle will deploy scientific and applications satellites of all types. Since it can carry payloads weighing up to 29,500 kilograms (65,000 pounds) it will replace most of the expendable launch vehicles currently used.

The Shuttle will be able to retrieve satellites from Earth orbit; to repair and redeploy them; or bring them back to Earth for refurbishment and reuse. It can also be used to carry out missions in which scientists and technicians conduct experiments in Earth orbit or service automated satellites already orbiting.

The National Aeronautics and Space Administration plans to develop the Shuttle over the next six years. Horizontal test flights are to begin in 1977, orbital test flights in 1979, and the complete vehicle is to be operational in 1980.

The Shuttle will provide an effective and economical means for the United States to utilize and advance its capabilities in space. It will reduce substantially the cost of space operations for civilian and defense needs in the decade of the 1980's and beyond.

The Shuttle will consist of a reusable orbiter, mounted piggy back at launch on a large expendable liquid propellant tank and two recoverable and reusable solid propellant rocket boosters. The orbiter will look like a delta-winged airplane, about the size of a DC-9 jet liner. It will have three liquid fueled rocket engines, a cargo bay 18 meters (60 feet) long and 4.5 meters (15 feet) in diameter, and will be operated by a crew of three. Wingspan will be about 24 meters (78 feet) and it will be about 37 meters (122 feet) long.

With the external tank attached, the total Shuttle vehicle will stand about 57 meters (184 feet) tall on the launch pad.

At launch, the two solid rockets and the orbiter's three liquid rocket engines will ignite and burn simultaneously. At an altitude of about 40 kilometers (approximately 25 statute miles) the spent solid rockets will be detached and parachuted into the ocean for recovery and reuse. Following solid rocket staging, the orbiter and its propellant tank will continue ascent. At main engine cutoff, the expendable propellant tank will be jettisoned into a remote ocean area. The orbiter then fires its orbital maneuvering system (OMS) for a short period to achieve orbital insertion. The orbiter with its crew and payload will remain in orbit to carry out its mission, normally for about seven days, but when required for as long as 30 days. When the mission is completed the orbiter will return to Earth and land like an airplane.

### Background

Extensive engineering, design, and cost studies of a Space Shuttle were initiated by NASA's Office of Manned Space Flight in early 1980. These studies covered a wide variety of concepts ranging from a fully reusable manned booster and orbiter to the concept employing an external propellant rockets which was selected. In-depth studies for each of several candidate concepts evaluated the development risk and cost in relation to the operational suitability and the overall economics of the entire system.

In July 1971, the Rocketdyne Division of North American Rockwell Corp., (now Rockwell International), was selected to develop the high pressure liquid oxygen, liquid hydrogen engines which provide the main propulsion for the orbiter.

On January 5, 1972, President Nixon announced that NASA should proceed with development of a reusable low cost Space Shuttle system. He said:

"This system will center on a space vehicle that can shuttle repeatedly from Earth to orbit and back. It will revolutionize transportation into near space, by routinizing it. It will take the astronomical costs out of astronautics. In short, it will go a long way toward delivering the rich benefits of practical space utilization and the valuable spinoffs from space efforts into the daily lives of Americans and all people. However, all these possibilities, and countless others with direct and dramatic bearing on human betterment, can never be more than fractionally realized so long as every single trip from Earth to orbit remains a

matter of special effort and staggering expense. This is why commitment to the Space Shuttle program is the right next step for America to take, in moving out from our present beach-head in the sky to achieve a real working presence in space -- because the Space Shuttle will give us routine access to space by sharply reducing costs in dollars and preparation time."

Intensive engineering studies were continued through January and February of 1972 by NASA and its aerospace industry contractors. These studies concentrated on the technical and economic aspects of using either a solid or liquid propellant rocket booster, and also the feasibility of a recoverable and reusable or an expendable system for either type of booster.

On March 15, 1972, Dr. James C. Fletcher, NASA Administrator, announced that the Shuttle would use twin solid propellant rocket motors which will be recoverable and reusable. The decision was based on information developed by the studies which showed that the solid rocket system offered lower development cost and lower technical risk.

The concept of the external propellant tank for the orbiter had a major impact. By making the orbiter much more efficient, it became possible to let the orbiter take more of the burden of propelling the Shuttle into orbit. Booster shutdown and staging separation could therefore occur at a much lower altitude and velocity. This important advantage presented the opportunity to use ballistic liquid rocket boosters or solid rocket motor boosters that are efficient at the lower staging velocities. Their use promised the greatest reduction in development costs. Of the two, the development costs of the solid rocket booster were estimated to be about \$700 million lower than those of the liquid rocket booster.

The final determination was that the solid rocket booster recoverable system with the orbiter liquid rockets firing in parallel would have the lowest total development cost (\$5.15 billion in 1971 dollars), least capital risk per flight, and lowest technical risk of development. Additionally, economic studies had shown that this system would provide the highest rate of return on investment.

A parallel burn, where booster and orbiter engines are ignited at lift-off, takes maximum advantage of the high performance orbiter engines and is particularly attractive for the solids where it is desirable to minimize their size for operational cost reasons.



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On March 17, 1972, NASA issued requests for proposals to industry for development of the orbiter vehicle and systems integration for the orbiter external propellant tank, solid rocket booster, and orbiter main engine.

On April 14, 1972, Dr. Fletcher announced the selection of the Kennedy Space Center in Florida and Vandenberg Air Force Base in California as the sites from which the Space Shuttle will be operated.

On July 26, 1972, North American Rockwell Corporation's (now Rockwell International) Space Division, Downey, California, was selected as prime contractor for design, development and production of the orbiter and its integration with all other elements of the Shuttle system.

On August 16, 1973, the Martin-Marietta Corporation, Denver Division, was selected to design, develop, test and evaluate the Shuttle external tank. This contract includes the fabrication of three ground test tanks and six development flight tanks.

The final major Shuttle contractor, Thiokol Chemical Corporation of Brigham City, Utah, was selected on November 20, 1973, to design, develop, test and evaluate the solid rocket motors. The proposed contract will include fabrication of ground test and development flight motors with a separate follow-on contract for the major engine production.

#### Space Shuttle Configuration

On the launch pad the Shuttle system will stand about half as tall as the Apollo-Saturn vehicle, and consist of four large elements clustered together; the expendable propellant tank, twin recoverable solid rocket booster (SRB's) and the orbiter vehicle. The solid rockets will be mounted to the tank at two points approximately 180 degrees apart. The tank, about 47 meters (154 feet) long and 8.4 meters (27.5 feet) in diameter, will be mounted beneath the orbiter.

The Shuttle can be held on a standby launch status for 24 hours and launched within two hours from the standby status. On standby status it will be ready for launch except for cryogenic propellant fill (liquid hydrogen and oxygen), crew ingress and final systems verification.

- more -

At launch the twin rocket booster, about 3.7 meters (12.2 feet) in diameter and 45.5 meters (149 feet) long will be ignited simultaneously with the liquid fueled orbiter engines and burn in parallel with the orbiter engines to an altitude of about 40 kilometers (25 statute miles). The solid rockets will then be detached, descend by parachutes, to be recovered, refurbished and reused. The solid rockets are expected to be capable of at least 20 reuses.

Total liftoff thrust is to be 27,316,000 newtons (6,141,000 pounds) made up of 1,668,000 newtons (375,000 pounds) from each of the three main engines at sea level and 11,156,000 newtons (2,508,000 pounds) from each of the two solid boosters.

Orbiter -- The orbiter will be about the size of a DC-9 aircraft, approximately 37 meters (122 feet) long and have a wing spread of 24 meters (78 feet). The cargo compartment, or payload bay, will be approximately 4.5 meters (15 feet) in diameter and 18 meters (60 feet) long. Maximum payload capability will be 29,500 kilograms (65,000 pounds) launched due East in a 278 kilometer (150 nautical mile) orbit. Cargo bay doors extending the full length of the cargo bay permit exposure or deployment of payloads.

The orbiter will be capable of landing on a conventional runway with a payload weighing up to 14,000 kilograms (32,000 pounds).

Unlike previous manned spacecraft the Shuttle orbiter will have reusable external insulation. Each vehicle will be designed to carry out at least 100 space missions without major overhaul.

After extended study and testing of passive thermal protection systems, reusable surface insulation materials were selected to reduce refurbishment requirements. For areas subjected to temperatures in the 1,922°K (3,000°F) range, an oxidation-inhibited carbon material will be used. It consists of pyrolyzed carbon fibers in a pyrolyzed carbon matrix with silicon carbide coating, and is commonly referred to as "carbon-carbon".

Intermediate heating areas (up to 1,533°K or 2,300°F) will be protected by high temperature reusable surface insulation tiles (HRSI), consisting of 99% pure felted silica fibers. These tiles range in thickness from 2.5 cm to 7.5 cm (1 to 3 inches). The tiles will be protected by a fritted borosilicate coating containing pigment to provide the desired absorptance/emittance ratios. For areas along the top and sides of the fuselage, where temperatures do not exceed 616°K (650°F) low-temperature reusable surface insulation will be used.

In normal operations, the personnel complement can vary from three to a maximum of seven. The basic crew consists of a pilot, co-pilot and mission specialist. For complex payload missions, up to four additional payload specialists can be carried. Accommodations are provided for both sexes. All will normally travel in shirt-sleeve comfort without space suits and undergo a maximum of 3 G forces during launch and reentry.

If required the orbiter will carry a docking module in the payload bay and will be capable of manual docking with other vehicles with compatible docking devices. The mission specialist will have access to the payload through an airlock leading into the payload compartment without depressurization of the orbiter cabin. He will then be able to check out and deploy certain payloads or conduct investigations requiring direct access to space.

On some flights a pressurized Spacelab, being developed by nine European countries at their expense, will be carried in the payload bay and will serve as a space laboratory. For the first time, scientists and engineers who are not astronauts will have an opportunity to accompany and conduct their experiments in space.

The Spacelab will be the means by which man-associated experiments are carried out in the Orbiter payload bay. Experiments can be assembled, checked out, and mated in advance and the Spacelab installed in the payload bay just prior to flight. The Spacelab will include a pressurized enclosure housing support equipment (to make it habitable) as well as the experimental equipment. When sensors require direct exposure to the space environment, a pallet will be used in association with the pressurized enclosure. On other types of missions, a pallet may be used alone, with the control of the instruments taking place from the Orbiter cabin or even from the ground. The Spacelabs are being designed around a basic seven-day mission which is extendable up to 30 days by trading off payload weight and volume for the additional consumables necessary to accommodate the additional time in orbit.

The Spacelab is being designed to meet the requirements of a broad spectrum of science and applications, domestic and foreign. It will provide a full complement of general support equipment and have provisions to accommodate a wide variety of specialized needs. The Spacelab is being developed in Europe with European funding under the auspices of the European Space Agency (ESA). It will be built by European industry under the management of VFW-FOKKER-ERNO of West Germany. The development will include the delivery of one flight unit and certain engineering and hardware support to NASA. NASA will purchase one or more additional Spacelabs from the Europeans.

## Space Shuttle Missions and Operational Capabilities

As the Shuttle becomes operational, it will carry into space virtually all of the nation's civilian and military payloads as well as many international civilian and government payloads. These include science and applications payloads for private industry, universities and research organizations.

Approximately 60 to 70 Shuttle missions each year will be required to handle the volume of space payloads anticipated in the 1980's.

Studies of potential Shuttle missions in this period indicate that about 38 percent are likely to be Spacelab missions with the remainder being the placement, revisit, or retrieval of automated spacecraft.

The 1973 Payload Model -- NASA's most recent analysis -- estimates that the distribution of activity in the 1980's will be approximately as follows:

Science -- Astronomy, physics, life sciences, lunar and planetary	34%
Applications -- Earth resources, communica- tions and navigation, space processing, etc.	35%
Department of Defense	31%

A typical scenario of the use of the Space Shuttle to place an automated satellite in low Earth orbit would be as follows: The Shuttle carries the spacecraft to the required altitude and inclination. The satellite is checked out thoroughly by a payload specialist to validate its operation in the environment of space. Adjustments and calibration of instruments and sensors are performed before the spacecraft is committed to its unattended operation. In the event the spacecraft fails to perform as planned and on-orbit repairs are inadequate, the spacecraft is returned to Earth for more extensive repairs. The same procedure is applied to malfunctioning spacecraft previously placed in orbit. Each spacecraft carried to orbit by the Shuttle thereby starts its on-orbit operation in functioning condition.

In a study of 131 satellite failures which have occurred in the past, 78 were related to launch problems. The remaining 53 failures were attributable to spacecraft anomalies. Most of these failures could have been avoided if the Shuttle had been available.

The size and weight-carrying capacity of the orbiter will free spacecraft designers from constraints which have made payload development very time consuming and costly. It will be possible to use relatively inexpensive construction materials and standard laboratory equipment in place of specially constructed, highly miniaturized components which are expensive to develop and test.

The Shuttle can be used to validate prototype instrumentation and sub-systems in the true space environment and return them to Earth for analysis and incorporation into spacecraft designs with operational assurance having been demonstrated.

The Shuttle will be capable of transporting payloads up to 500 miles in Earth orbit. However, there are many space missions which require higher orbits. To achieve these higher orbits, a Space Tug is required. The Space Tug will be a reusable stage that will fit in the Shuttle cargo bay with its payload and will provide the capability to place and retrieve payloads in orbits beyond the capability of the Shuttle and achieve Earth escape velocities for transplanetary spacecraft. A tentative agreement has been reached between NASA and the Department of Defense for the DOD to develop an initial upper stage called an Orbit-to-Orbit Stage using existing technology and/or components. This stage will not have a payload retrieval capability but may be reusable. It will be available when the Shuttle becomes operational in 1980.

While this initial upper stage is developed by the Air Force, NASA will continue planning for the later development and timely introduction of a reusable, full capability Space Tug. This Space Tug will provide for payload retrieval or on-orbit servicing to ultimately meet the needs of all users.

Appropriations (millions) -- Space Shuttle Program

	<u>Research &amp; Development</u>	<u>Construction of Facilities</u>	<u>Total</u>
FY 1970	\$ 12.5	\$	\$ 12.5
FY 1971	78.5	1.5	80.0
FY 1972	100.0	18.5	118.5
FY 1973	198.6	27.9	226.5
FY 1974	475.0	56.3	531.3
FY 1975	800.0	77.0	877.0
	<hr/>	<hr/>	<hr/>
	\$1,664.6	\$181.2	\$1,845.8



### Space Shuttle Program Management

Overall direction of the program is in the Space Shuttle Program Office, Office of Manned Space Flight, which is responsible for detailed assignment of responsibilities, basic performance requirements, control of major milestones and funding allocations to the various NASA field centers.

The Johnson Space Center (JSC), Houston, has program management responsibility for program control, overall systems engineering and systems integration, and overall responsibility and authority for definition of those elements of the total system which interact with other elements, such as total configuration and combined aerodynamic loads. JSC also is responsible for development, production, and delivery of the Shuttle orbiter and manages the contract with Rockwell International.

Kennedy Space Center, Fla., is responsible for design of launch and recovery facilities, and will serve as the launch and landing site for the Space Shuttle development flight and for operational missions requiring launches in an easterly direction.

Marshall Space Flight Center (MSFC), Huntsville, Ala., is responsible for the development, production and delivery of the orbiter main engine, the solid booster, and the hydrogen-oxygen propellant tank. MSFC also will accomplish and/or manage certain other Shuttle tasks where the Center also has unique capabilities.

### Launch and Landing Site

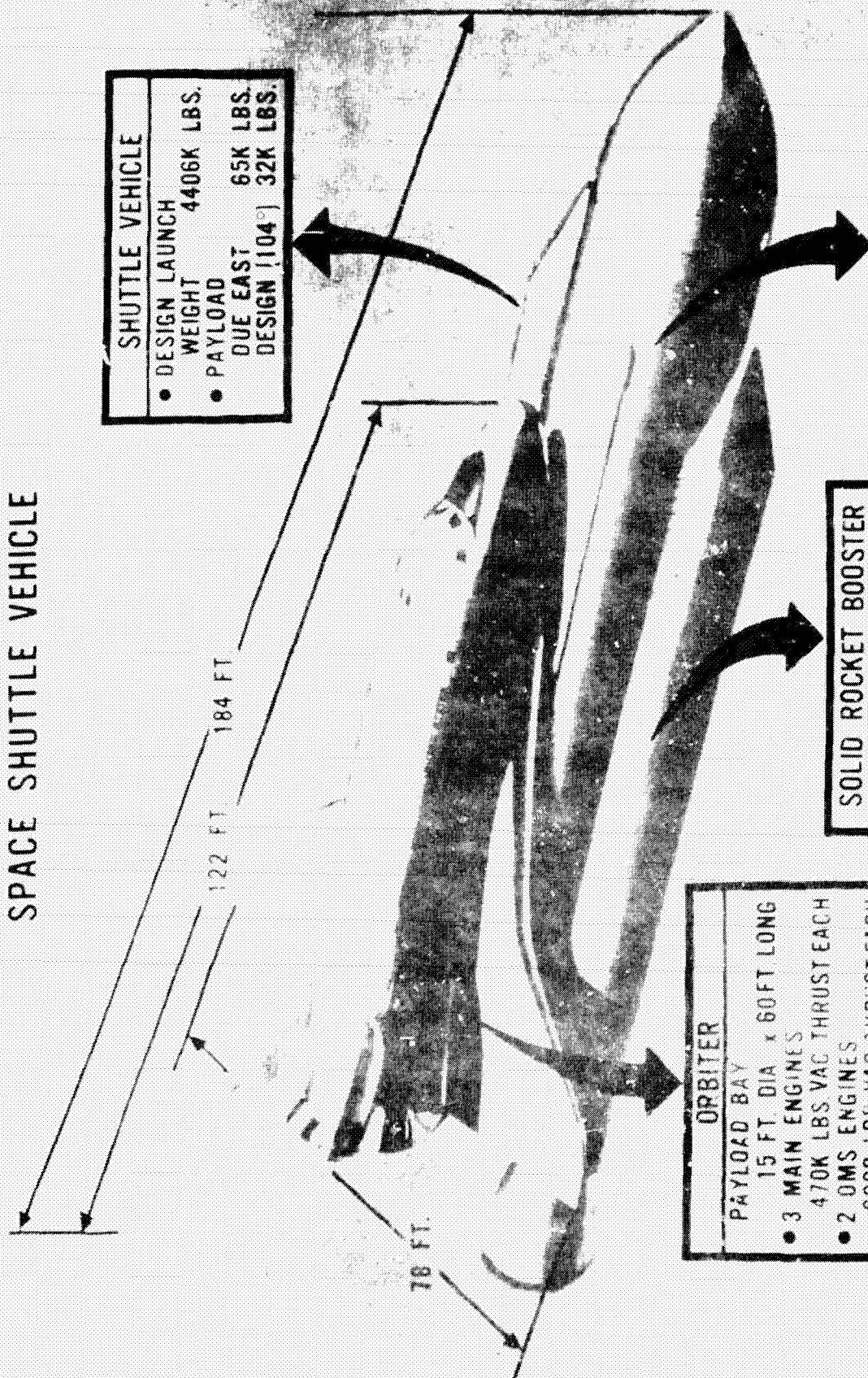
A Space Shuttle launch site evaluation board studied possible launch sites throughout the United States for more than one year. More than 150 sites were considered, and 80 have been studied in detail for all possible requirements and contingencies applicable to the Shuttle.

The decision was made in April, 1972, that:

1. The initial launch and recovery site will be at Kennedy Space Center, Fla., and be used for research and development launches and for all easterly operational launches feasible from KSC. General purpose Shuttle facilities for all users will be provided by NASA at KSC on a time schedule compatible with the Shuttle development program.

2. A second operational site for missions requiring high inclination launches not feasible from KSC is planned at Vandenberg Air Force Base toward the end of the 1970s. General purpose Shuttle facilities for all users will be provided by the Department of Defense at Vandenberg Air Force Base on a time schedule compatible with progress in the Shuttle development program and timely utilization of the Shuttle for operational missions requiring high inclination launches.

# SPACE SHUTTLE VEHICLE



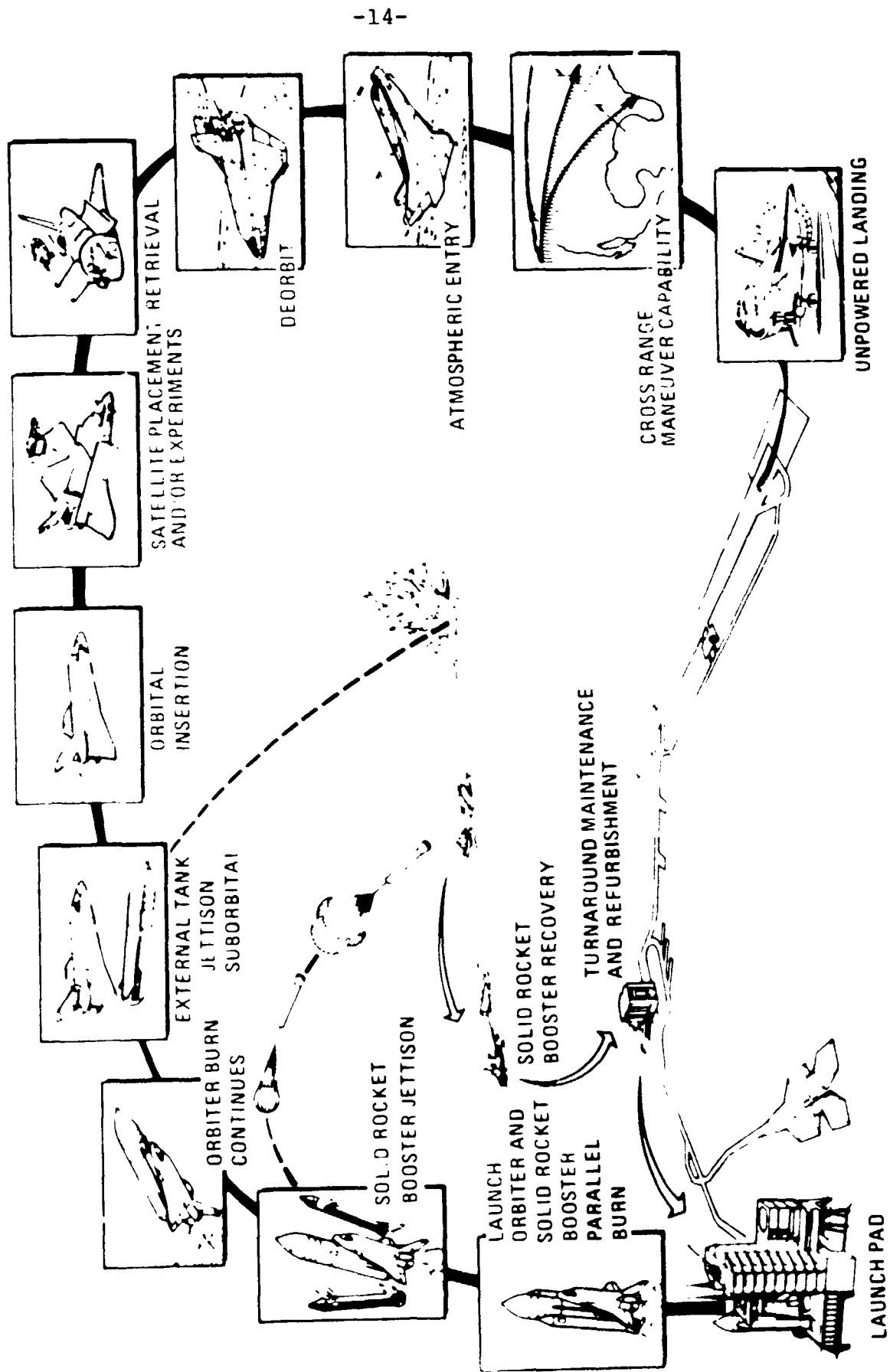
SHUTTLE VEHICLE	
• DESIGN LAUNCH WEIGHT	4406K LBS.
• PAYLOAD DUE EAST DESIGN (104°)	65K LBS. 32K LBS.

EXTERNAL TANK	
• LENGTH	153.7 FT.
• DIAMETER	331.0 IN.
• WEIGHT LAUNCH DRY	1619K LBS. 69K LBS.

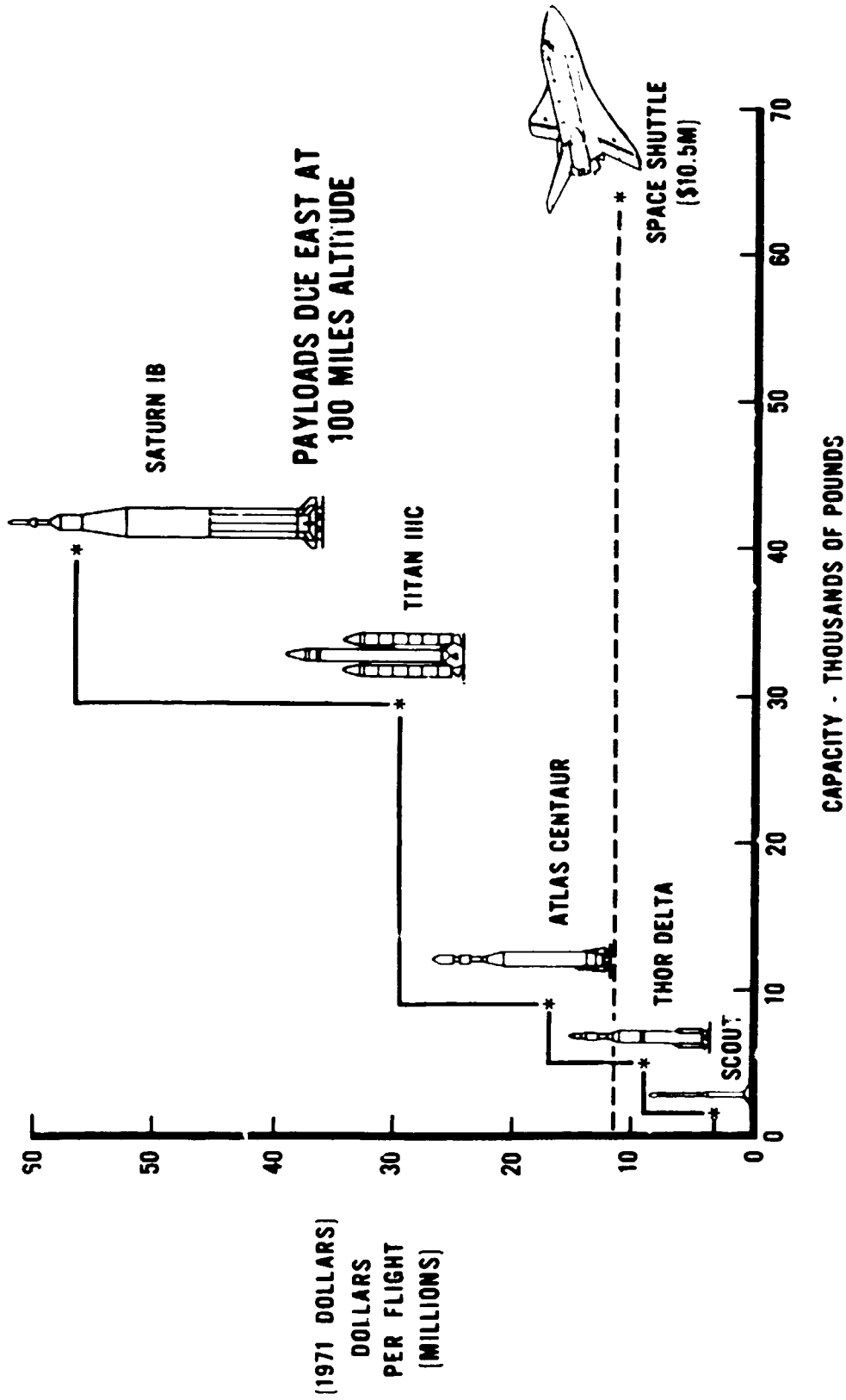
SOLID ROCKET BOOSTER	
• LENGTH	149.1 FT.
• DIAMETER	146 IN.
• WEIGHT LAUNCH INERT	1265K LBS EACH 182K LBS.
• THRUST LAUNCH	2.7M LBS. EACH

ORBITER	
PAYLOAD BAY	15 FT. DIA x 60 FT. LONG
• 3 MAIN ENGINES	470K LBS VAC THRUST EACH
• 2 OMS ENGINES	6000 LBS VAC THRUST EACH
• 36 RCS ENGINES	870 LBS VAC THRUST EACH
• 6 RCS VERNIER ENGINES	25 LBS. VAC THRUST EACH
• WEIGHT DRY	150K LBS
DESIGN LANDING	188K LBS

# SPACE SHUTTLE MISSION PROFILE



# COMPARATIVE LAUNCH COSTS



## **MISSION CAPABILITIES**

### **● MISSION DURATION**

BASELINE -7 DAYS WITH 4 CREWMEN  
WITH KITS - UP TO 30 DAYS WITH UP TO 7 CREWMEN

### **● MISSION STATIONS**

COMMANDER

PILOT

MISSION SPECIALISTS

UP TO 4 PAYLOAD SPECIALISTS

### **● CREW/PASSENGER PROVISIONS**

14.7 PSI "EARTH ATMOSPHERE"  
TEMPERATURE / HUMIDITY / CO<sub>2</sub> CONTROL  
HOT AND COLD FOOD  
PROTECTED SLEEP STATIONS  
MALE AND FEMALE HYGIENE FACILITIES  
3G MAXIMUM ACCELERATION

### **● EVA CAPABILITY FOR PAYLOAD SUPPORT**

TWO SUITED CREWMEN (BUDDY SYSTEM)  
MISSION SPECIALIST PRIME COMMANDER OR PILOT ASSIST



# SPACE SHUTTLE FACILITY LOCATIONS

FLIGHT RESEARCH CENTER  
(EDWARDS AFB)

BRIGHAM CITY, UTAH

- APPROACH & LAND'G FLT. TEST

- SOLID ROCKET MOTOR

PALMDALE

- ORBITER FINAL ASSEMBLY

VANDENBERG AFB

- LAUNCH & LANDING

CANOGA PARK

- MAIN ENGINE MFG

SANTA SUSANNA

- ENGINE COMP. TEST

DOWNEY INDUST. PLANT

- ORBITER SUBASSEMBLY & COMPONENT MANUFACTURE & TEST

WHITE SANDS TEST FAC

- TESTS OF:

- ORBITAL MANEUVERING ENG.
- ORBITAL MANEUVERING SYS.
- REACTION CONTROL SYSTEM
- MATERIALS

JPL SPACE CENTER

- PROGRAM MANAGEMENT
- MISSION CONTROL
- TRAINING
- AVIONICS
- TPS TESTS
- VIB. & ACCUSTIC TESTS

MICHOUD ASS'Y FAC

- EXTERNAL TANK ASSEMBLY

NAT'L. SPACE TECH.

LABS (NSTL)

- MAIN ENGINE TEST

KENNEDY SPACE CTR.

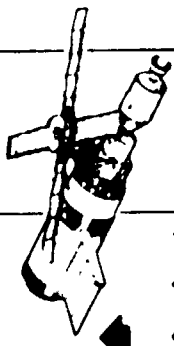
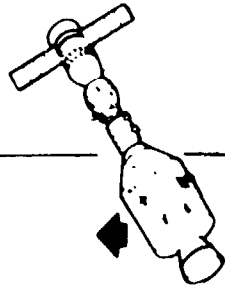
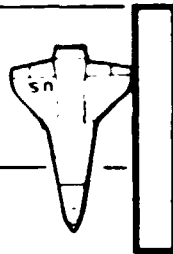
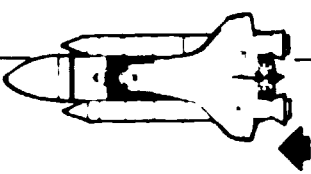
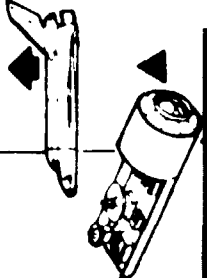
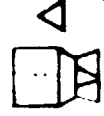
- LAUNCH & LANDING

MARSHALL

SPACE FLT CTR

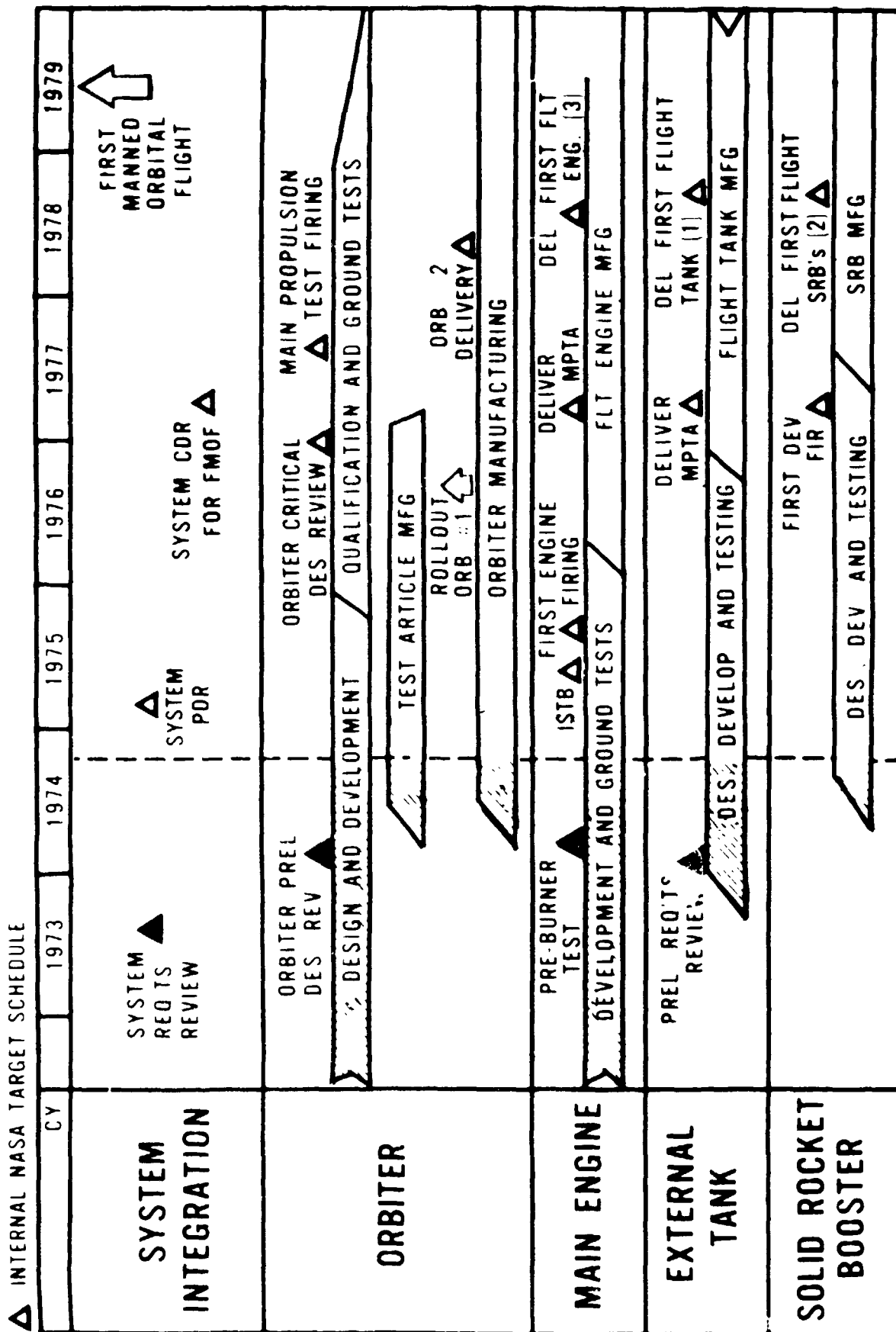
- EXT TANK STRUCT TEST
- SRB STRUCT TEST
- GROUND VIB. TEST

# MANNED SPACE FLIGHT FLIGHT ACTIVITY

PROGRAMS	1973	1974	1975	1976	1977	1978	1979	1980
SKYLAB	 (28) (59) (84) (DAYS)							
WORKSHOP								
MANNED								
ASTP								
SHUTTLE								
APPROACH & LANDING TEST FLIGHTS								
FIRST MANNED ORBITAL FLIGHT								
OPERATIONAL								
SPACELAB (EUROPE)								
PAYLOADS								
ORBIT TO ORBIT STAGE (USAF) *								

\* TENTATIVE AGREEMENT

# SPACE SHUTTLE DEVELOPMENT PLAN



MPTA MAIN PROPULSION TEST ARTICLE  
ISTB INTEGRATED SYSTEMS TEST BED

## SHUTTLE PROGRAM CONTRACTS

- MAIN ENGINE-ROCKWELL INTERNATIONAL-ROCKETDYNE DIVISION CALIFORNIA
  - CONTROLLER \_\_\_\_\_ HONEYWELL-MINNESOTA FLORIDA
  - HYDRAULIC ACTUATOR \_\_\_\_\_ HYDRAULIC RESEARCH INC-CALIFORNIA
- EXTERNAL TANK-MARTIN MARIETTA (NASA MICHoud ASSEMBLY FACILITY, LOUISIANA)
- SOLID ROCKET MOTOR-THIokol (WASATCH DIVISION)-UTAH
- ORBITER SOFTWARE PROGRAMMING-IBM-TEXAS
- SHUTTLE TRAINING AIRCRAFT-GRUMMAN NEW YORK
- KSC DESIGN ENGINEERING AND SUPPORT-PRC, FLORIDA
- LPS SOFTWARE DEVELOPMENT-IBM-NEW YORK
- ENGINEERING OPERATIONS SUPPORT-MDAC, MISSOURI
- CARRIER AIRCRAFT-AMERICAN AIRLINES, OKLAHOMA

## MAJOR ORBITER SUBCONTRACT AWARDS

- ORBITER SYSTEM INTEGRATION PRIME CONTRACT-ROCKWELL INTERNATIONAL -  
SPACE DIVISION, CALIFORNIA

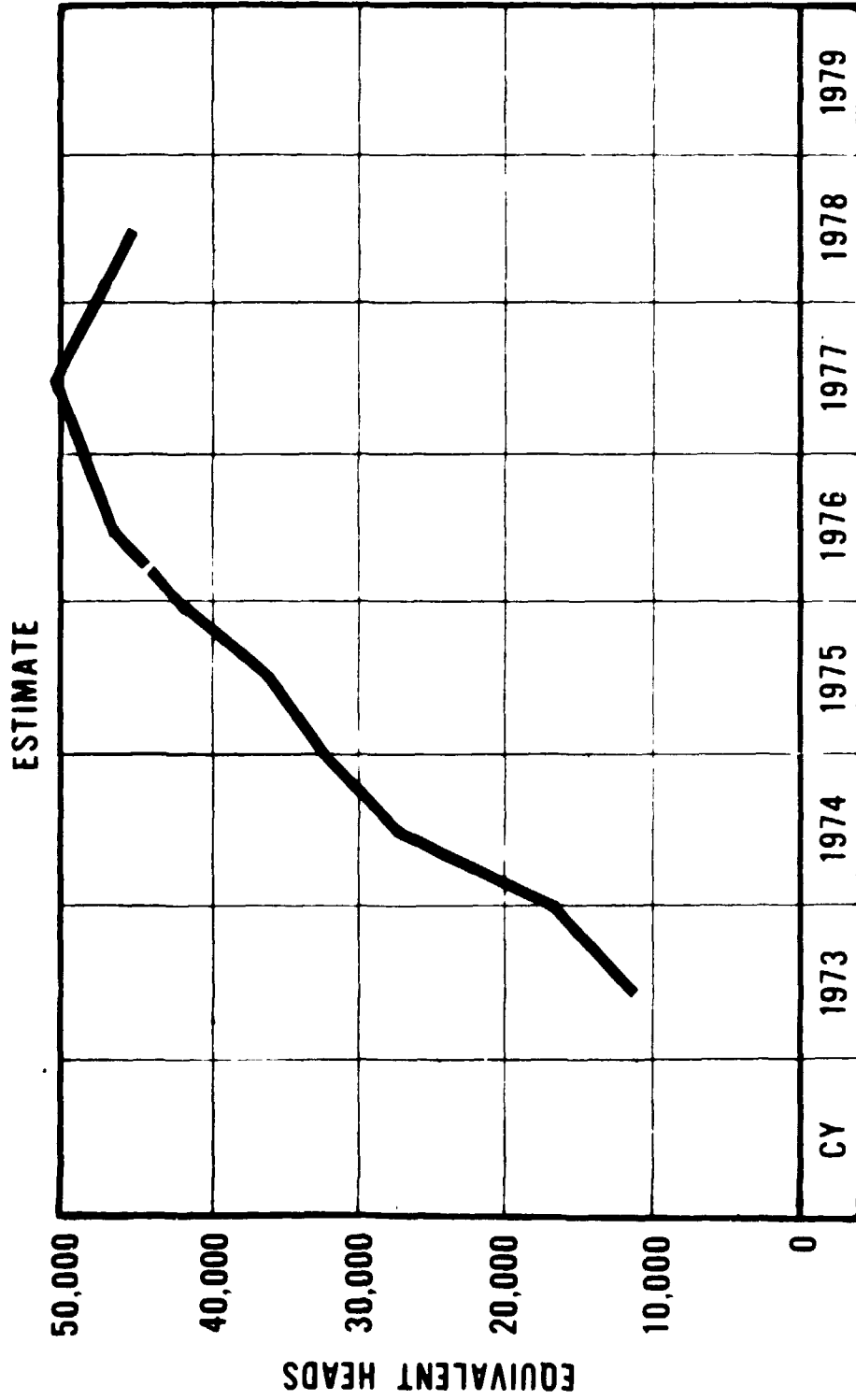
- FLIGHT CONTROL SYSTEMS \_\_\_\_\_ HONEYWELL-MINNESOTA FLORIDA
- DATA PROCESSING & SOFTWARE REQUIREMENTS \_\_\_\_\_ IBM-NEW YORK
- OMS RCS AFT INTEGRATED MODULE \_\_\_\_\_ MDAC-MISSOURI
- VERTICAL STABILIZER \_\_\_\_\_ REPUBLIC-NEW YORK
- WING \_\_\_\_\_ GRUMMAN-NEW YORK
- MID-FUSELAGE \_\_\_\_\_ GENERAL DYNAMICS-CALIFORNIA
- GROUND MAINTENANCE & OPERATIONS SUPPORT \_\_\_\_\_ AMERICAN AIRLINES-OKLAHOMA
- REUSABLE SURFACE INSULATION \_\_\_\_\_ LOCKHEED-CALIFORNIA
- LEADING EDGE STRUCTURAL SUBSYSTEM TPS \_\_\_\_\_ LTV-TEXAS
- ATM. REVITALIZATION-THERMAL HEAT TRANSPORT \_\_\_\_\_ HAMILTON STANDARD-CONNECTICUT
- ONBOARD COMPUTER INPUT OUTPUT BUFFER \_\_\_\_\_ IBM-NEW YORK
- POWER REACTANT STORAGE ASSEMBLY \_\_\_\_\_ BEECH AIRCRAFT-COLORADO
- OMS ENGINES \_\_\_\_\_ AEROJET-CALIFORNIA
- AUXILIARY POWER UNIT \_\_\_\_\_ SUNDSTRAND-ILLINOIS
- MULTIPLEXER DEMULTIPLEXER \_\_\_\_\_ SPERRY-ARIZONA
- RCS THRUSTERS \_\_\_\_\_ MARQUARDT-CALIFORNIA
- CARRIER AIRCRAFT MODIFICATION \_\_\_\_\_ BOEING-WASHINGTON

## OTHER ORBITER SUBCONTRACT AWARDS

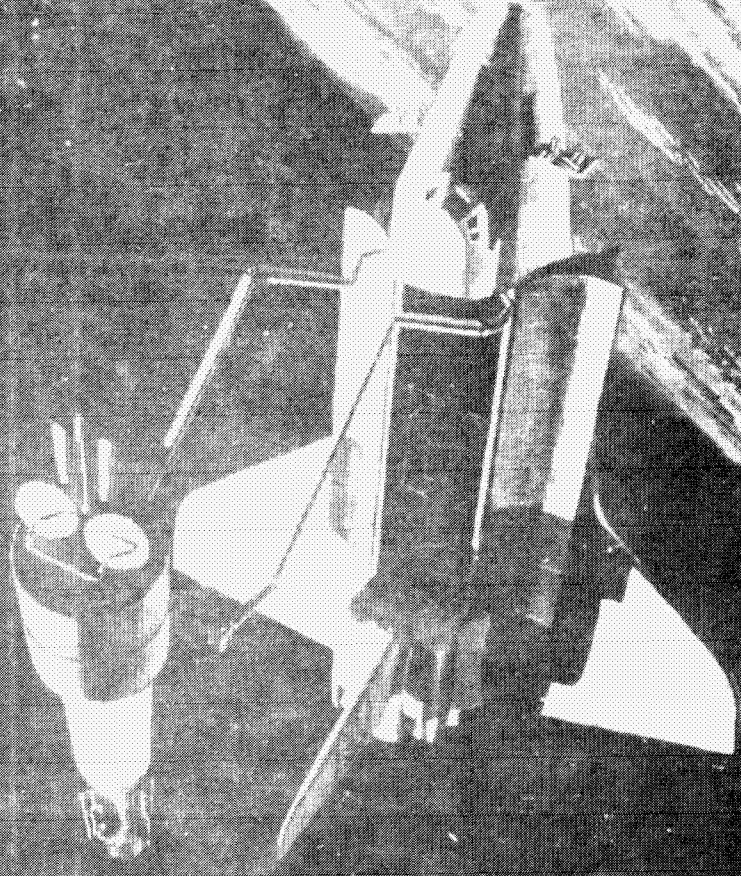
- AUTO LAND \_\_\_\_\_ SPERRY ARIZONA
- WINDOWS WINDSHIELDS \_\_\_\_\_ CORNING NEW YORK
- INERTIAL MEASUREMENT UNIT \_\_\_\_\_ SINGER KEARFOTT-NEW JERSEY
- ANALOG COMPUTER SYSTEM \_\_\_\_\_ ELECTRONICS ASSOC NEW JERSEY
- DIGITAL COMPUTER SYSTEM \_\_\_\_\_ XEROX-CALIFORNIA
- FUEL CELL POWER PLANT \_\_\_\_\_ PRATT & WHITNEY-CONNECTICUT
- MAIN & NOSE LANDING GEAR STRUCTURE \_\_\_\_\_ MENASCO-CALIFORNIA
- WHEELS & BRAKES \_\_\_\_\_ B F GOODRICH-OHIO
- DATA ACQUISITION SYSTEM \_\_\_\_\_ MOD COMP SYSTEMS-FLORIDA
- SERVO ACTUATORS \_\_\_\_\_ HYDRAULIC RESEARCH & MFG-CALIFORNIA
- MULTIPLEXER INTERFACE ADAPTER \_\_\_\_\_ SINGER KEARFOTT-NEW JERSEY
- RUDDER SPEED BRAKE ACTUATOR \_\_\_\_\_ SUNDSTRAND-ILLINOIS
- SMOKE DETECTION SYSTEM \_\_\_\_\_ CELESCO INDUSTRIES-CALIFORNIA
- MAIN ENGINE GIMBAL ACTUATOR \_\_\_\_\_ MOOG, INC-NEW YORK
- NAVIGATION SET \_\_\_\_\_ AIL CUTLER-HAMMER-NEW YORK
- POTABLE & WASTE TANKS \_\_\_\_\_ METAL BELLOWS CO-CALIFORNIA
- RCS TANKS \_\_\_\_\_ MARTIN-COLORADO
- TACAN \_\_\_\_\_ HOFFMAN ELECTRONICS-CALIFORNIA
- PULSE CODE MODULATOR \_\_\_\_\_ HARRIS ELECTRONICS-FLORIDA
- RATE GYRO ASSEMBLY \_\_\_\_\_ NORTHRUP-MASSACHUSETTS
- ATTITUDE DIRECTION INDICATOR \_\_\_\_\_ LEAR SIEGLER-MICHIGAN
- MASTER TIMING UNIT \_\_\_\_\_ WESTINGHOUSE ELECTRIC-MARYLAND
- ENGINE INTERFACE UNIT \_\_\_\_\_ CONRAC CORP-NEW JERSEY
- AMMONIA BOILER \_\_\_\_\_ FAIRCHILD STRATOS CALIFORNIA
- THERMAL CIRCUIT BREAKERS \_\_\_\_\_ AIKEN INDUSTRIES-MICHIGAN
- POWERSTATIC INVERTER \_\_\_\_\_ WESTINGHOUSE OHIO



# SPACE SHUTTLE PROGRAM CONTRACTOR MANPOWER



# SPACECRAFT DELIVERY AND REVISIT



- DEPLOY
- CHECKOUT
- SERVICE
- RETRIEVE



